

Lisbon Falls South Quadrangle, Maine

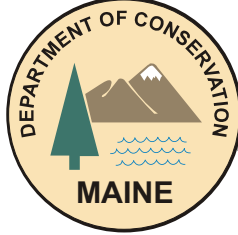
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SURFICIAL GEOLOGY OF MAINE

Continental glaciers like the ice sheet now covering Antarctica probably extended across Maine several times during the Pleistocene Epoch, between about 1.5 million and 10,000 years ago. The slow-moving ice superficially changed the landscape as it scraped over mountains and valleys, eroding and transporting boulders and other rock debris for miles. The sediments that cover much of Maine are largely the product of glaciation. Glacial ice deposited some of these materials, while others washed into the sea or accumulated in meltwater streams and lakes as the ice receded. Earlier stream patterns were disrupted, creating hundreds of ponds and lakes across the state. The map at left shows the pattern of glacial sediments in the Lisbon Falls South quadrangle.

The most recent "Ice Age" in Maine began about 25,000 years ago, when an ice sheet spread southward over New England (Stone and Borns, 1986). During its peak, the ice was several thousand feet thick and covered the highest mountains in the state. The weight of this huge glacier actually caused the land surface to sink hundreds of feet. Rock debris frozen into the base of the glacier abraded the bedrock surface over which the ice flowed. The grooves and fine scratches (striations) resulting from this scraping process are often seen on freshly exposed bedrock, and they are important indicators of the direction of ice movement. Erosion and sediment deposition by the ice sheet combined to give a streamlined shape to many hills, with their long dimension parallel to the direction of ice flow. Some of these hills (drumlins) are composed of dense glacial sediment (till) plastered under great pressure beneath the ice.

A warming climate forced the ice sheet to start receding as early as 21,000 years ago, soon after it reached its southernmost position on Long Island (Sirkin, 1986). The edge of the glacier withdrew from the continental shelf east of Long Island and reached the present position of the Maine coast by 13,800 years ago (Dorion, 1993). Even though the weight of the ice was removed from the land surface, the Earth's crust did not immediately spring back to its normal level. As a result, the sea flooded much of southern Maine as the glacier retreated to the northwest. Ocean waters extended far up the Kennebec and Penobscot valleys, reaching present elevations of up to 420 feet in the central part of the state.

Great quantities of sediment washed out of the melting ice and into the sea, which was in contact with the receding glacier margin (Figures 1-3). Sand and gravel accumulated as deltas and submarine fans where streams discharged along the ice front, while the finer silt and clay dispersed across the ocean floor. The shells of clams, mussels, and other invertebrates are found in the glacial-marine clay that blankets lowland areas of southern Maine (Figure 4). Age dates on these fossils tell us that ocean waters covered parts of Maine until about 11,000 years ago, when the land surface rebounded as the weight of the ice sheet was removed.

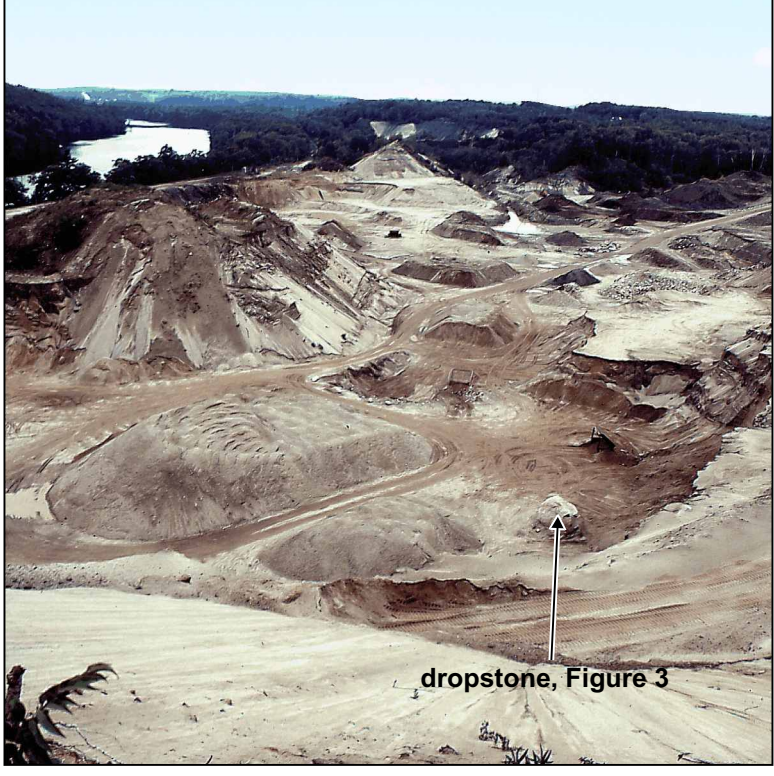


Figure 1. At **Locality 1**, several glaciomarine fans (Pmfp) were deposited when the glacier margin was at the site. Fossil shells found in similar deposits (Pemfl) to the south provided radiocarbon ages of about 14,000 yr B.P., inferring the time when the glacier retreated from the region. The photo shows the working gravel pits and extent of the glaciomarine fans. View to north with Androscoggin River in background.

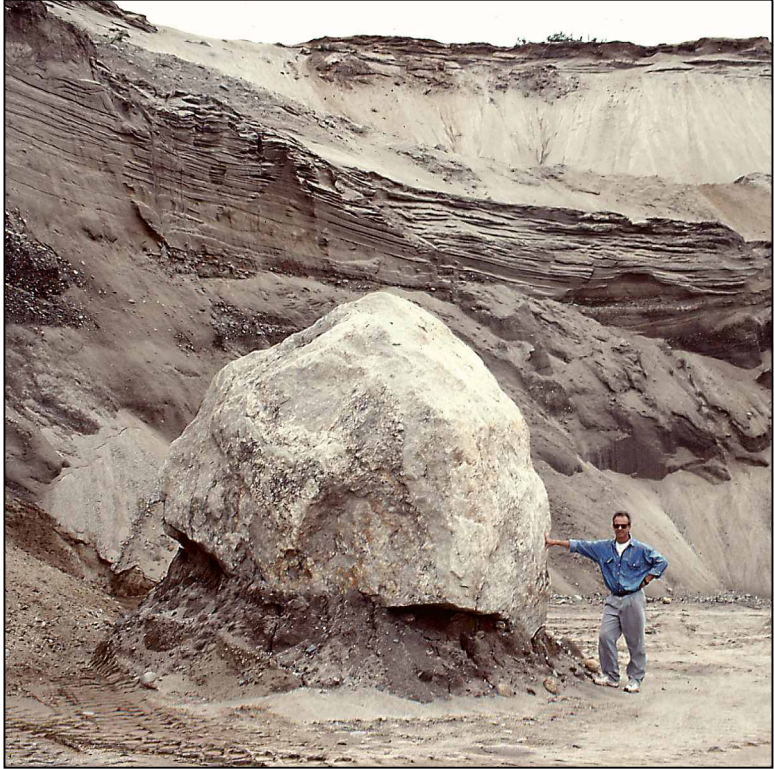


Figure 3. The large boulder in this photo is a dropstone found in the finer grained sediment of the middle part of the fan in **Locality 1**. The boulder probably was deposited from a melting iceberg floating in the sea, which at this time was as high as 300 feet elevation. The shoreline deposit shown in Figure 7 provides an estimate of sea level at this time, which was about 100 feet over the top of the fan in which the boulder was found.



Figure 5. Meltwater streams flowing in tunnels in the glacier transported sediment to the ocean. These tunnels often became choked with sediment, and after the ice melted, the resulting deposit formed an esker. In the glaciomarine environment, the coarse-grained esker may become buried by younger glaciomarine fan deposits, as is shown in the photo above (photo by Ilya Buynevich).



Figure 7. **Locality 3** is the site of a marine shoreline feature (Pms), a beach, represented by a break in slope on a sandy deposit found at about 300 ft elevation 3/4 mile southwest of Cox Pinnacle at Lunt Memorial Cemetery. The beach approximates the highstand of the glacial sea in the region.

Meltwater streams deposited sand and gravel in tunnels within the ice (Figure 5). These deposits remained as ridges (eskers) when the surrounding ice disappeared. Maine's esker systems can be traced for up to 100 miles, and are among the longest in the country.

Other sand and gravel deposits formed as mounds (kames) and terraces adjacent to melting ice, or as outwash in valleys in front of the glacier. Many of these water-laid deposits are well layered, in contrast to the chaotic mixture of boulders and sediment of all sizes (till) that was released from dirty ice without subsequent reworking. Ridges consisting of till or washed sediments (moraines) were constructed along the ice margin in places where the glacier was still actively flowing and conveying rock debris to its terminus (Figure 6). Moraine ridges are abundant in the zone of former marine submergence, where they are useful indicators of the pattern of ice retreat.

The last remnants of glacial ice probably were gone from Maine by 10,000 years ago. As the glacier left the region, the land emerged from the sea as a result of glacial unloading, a response of the earth's crust to the weight of the ice. Nearshore reworked deposits are the result of the land surface passing through the shore zone (Figures 7, 8). Large sand dunes accumulated in late-glacial time as winds picked up outwash sand and blew it onto the east sides of river valleys, such as the Androscoggin and Saco valleys. The modern stream network became established soon after deglaciation, and organic deposits began to form in peat bogs, marshes, and swamps. Tundra vegetation bordering the ice sheet was replaced by changing forest communities as the climate warmed (Davis and Jacobson, 1985). Geologic processes are by no means dormant today, however, since rivers and wave action modify the land, and worldwide sea level is gradually rising against Maine's coast.

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Figure 2. The sediments in this photo from **Locality 1** are located in the middle of the glaciomarine fan. The layering is characteristic of high-energy discharge of sediment, which avalanched rapidly down the slope of the fan in a sheet-like flow. The dune-shaped features in the center of the exposure may be sedimentary structures known as antidunes, which form under high-energy depositional conditions. Flow direction is from right to left in photo.



Figure 4. Shells (about 1.5 inches long) of the mollusc *Hiatella arctica* from **Locality 1**. The molluscs are found in glaciomarine mud, which was deposited when the sea covered the region during deglaciation. Other molluscs found at an elevation of 190 feet at this locality had a radiocarbon age estimated at 13,240 +/- 190 yr B.P. This age provides an estimate for when sea level was close to that elevation.



Figure 6. The Cox Pinnacle moraine (Pemcp) is unusual for southwestern Maine by virtue of its length, size, and continuity. It traces the position of the ice margin over Cox Pinnacle where it was pinned to the highland. In places, large boulders protrude from its crest (shown in photo, **Locality 2**).

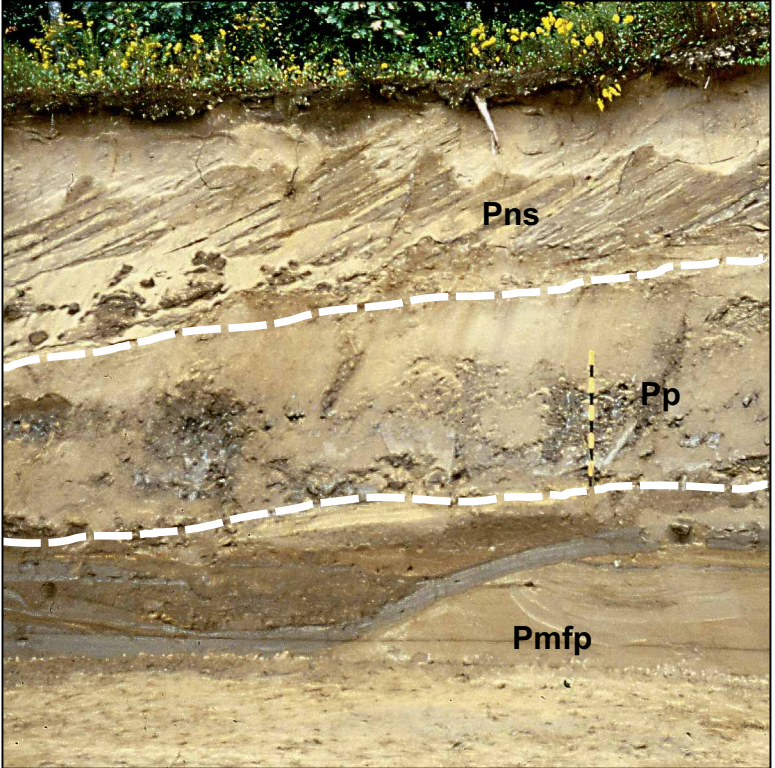


Figure 8. Cross-bedding in a nearshore deposit (Pns), possibly a spit, which overlies glaciomarine mud (Pp). The mud was deposited in the sea after the glacier receded. Below the mud is layered sand and mud, part of the glaciomarine fan (Pmfp) at **Locality 2**. This deposit is at a lower elevation than the beach in Figure 7. It shows the effect of waves on the landscape as it emerged from the glacial sea (**Locality 4**; photo by Joseph Kelley).